ELECTROMYOGRAPHY

Electromyography (EMG) is the detection and recording of the electrical signal produced by muscle tissue as it contracts.

Many uses of EMG

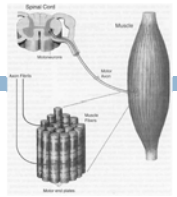
Why Record EMG?

- Emotion Research
  - Facial "expressions"
  - Bodily expressions
  - Motivational tendencies
- Cognitive Research
  - Processing effort
  - Verbalization
  - Response tendencies (e.g., mirroring, errors, etc)
- Health research:
  - Muscle tension in disorders and stress

What is EMG signal?

- Electricity generated by *Muscle Action Potentials* (MAPs).
- Or more technically:
  - "EMG records the changes in electrical potential that result from the conduction of action potentials along the muscle fibers, or rather the motor units during muscle contraction (MUAP – motor unit action potential)." Hess, 2009
- Most psychologists use "*surface EMG*", measuring small currents conveyed to surface via extra cellular fluids to skin.
  - However, one can also record invasively with subcutaneous needle electrodes

Innervation



- Muscle needs stimulation to contract
- The motor nerve
  - Contains many motoneurons
  - Each motoneuron branches into several axon fibrils
- At end of each axon fibril is a junction with the muscle fiber known as the **motor endplate**

The bottom line

- In general, the stronger the muscle activity, the more action potentials, the stronger the EMG signal.
- Other factors
  - Skin impedance (preparation)
  - Subcutaneous fat (insulator)
  - Muscle size
  - Distance to electrodes and between electrodes
  - Alignment of electrodes (with respect to muscle fiber direction)

Some cautions

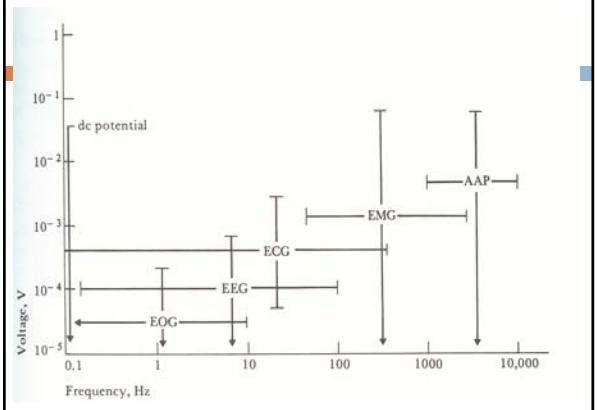
- EMG is not absolute; it is a relative measure only.
- Based on voltage value of EMG, we cannot compare directly between muscles or between people.
- We can use EMG values to compare between different conditions for same muscle.
- Converting values to standardized (z) scores within subjects and within muscles, can facilitate comparisons.

EMG recording

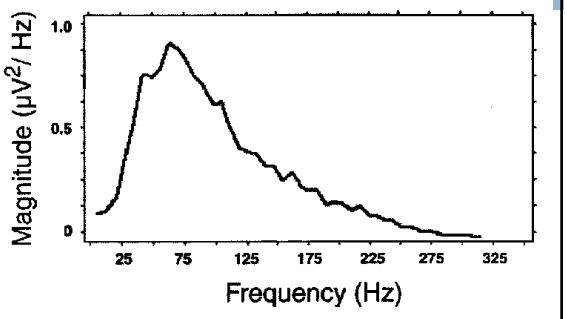
- The small signals detected by the active pair of electrodes on the surface of the skin are compared to the signal detected by a reference electrode placed over connective tissue (especially bone). This reference electrode may be called a "ground" or "earth" electrode.

Signal Recording

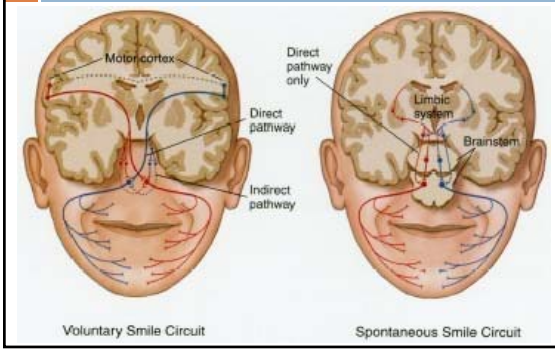
- To produce a smooth contraction, there is overlapping of motor unit firing (5-100 pulses/s but commonly 10-30 pulses/s).
- There are asynchronous volleys of impulses traveling down the many axons innervating a single muscle
- MAPs summate in quasi-random, "noise-like" fashion to produce resultant signal.
  - Range of ~10-500 Hz
  - Amplitude of sub-microvolt to around 1000 microvolts



EMG Power



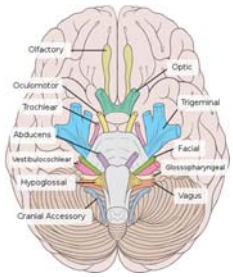
Brain control of voltary and spontaneous smiles



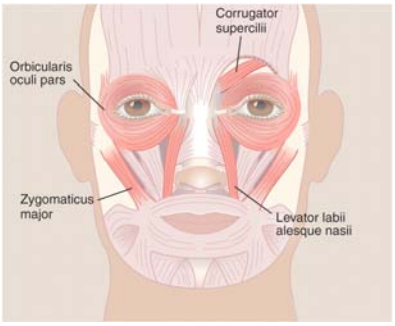
Möbius syndrome

- results from the underdevelopment of the VI and VII cranial nerves

1 in 100,000



Basic muscles of facial expressions



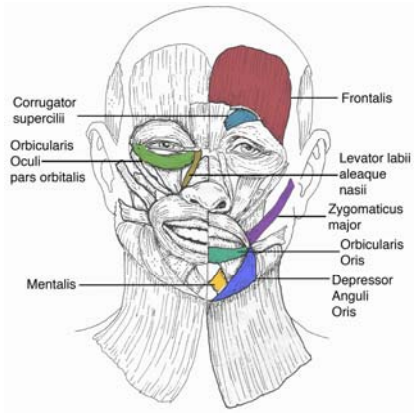


Fig 2 a

EMG can measure reflexes

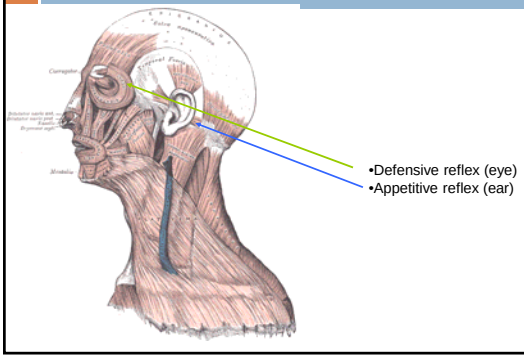


Fig 4

postauricular muscle

- auricularis posterior -- draws the ear backward

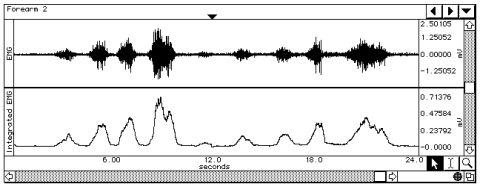
Basics of signal recording

Signal Recording (cont')

- Amplification
  - Differential amplifiers with common mode rejection
  - Actually double differential (electrodes against each other, and against ground)
- Sample at 4x the highest frequency (i.e. 2000 Hz)
- Amplify voltages 1000-20,000 times and digitize the signal.
- May record wide frequency and filter off-line, may use on-line filter
  - Should pass 10-500 Hz (the energy above 250Hz is negligible)

EMG quantification

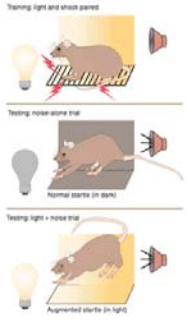
- Full-wave rectify the signal (all negative voltages are converted to positive)
- Integrate the signal by calculating the area under the curve during a certain period



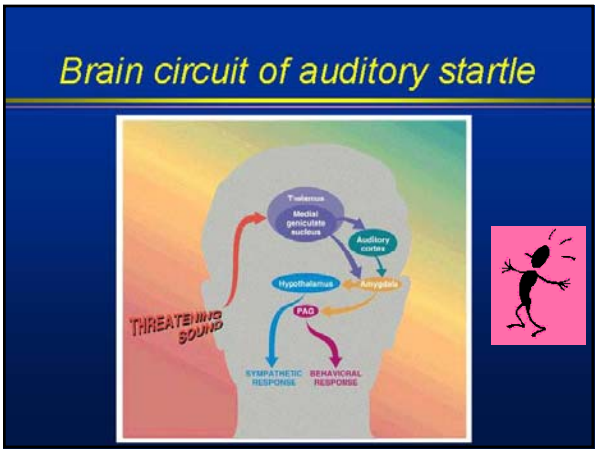
EMG uses

Startle

- Method Used by Davis and His Colleagues to Investigate the Augmented Startle Response



Brain circuit of auditory startle

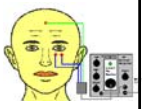


Procedure of startle modification study

54 Pictures from IAPS and faces:

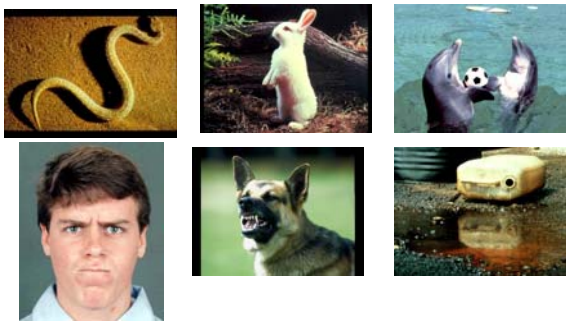
- Positive
- Neutral
- Negative

Startle:
-Loud 96 db noise presented for 50 ms. after picture onset at varying intervals (around 3 seconds)

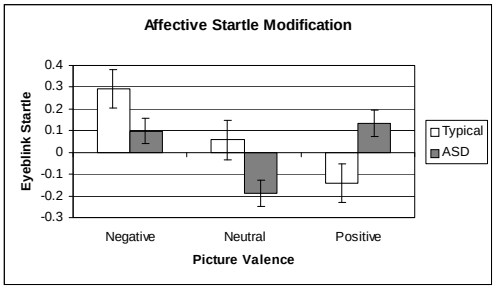


Measures:
- Blink response (obicularis, 30-120 ms)
- Facial electromyography (zygomaticus,corrugator)
- Rating of the picture (1 = positive, 9 = negative scale)

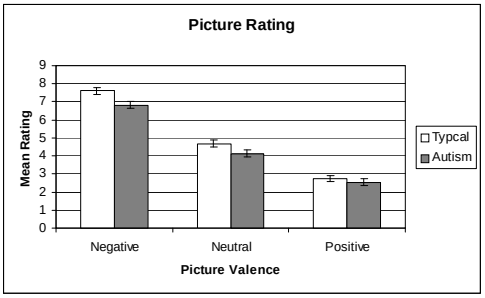
Stimuli



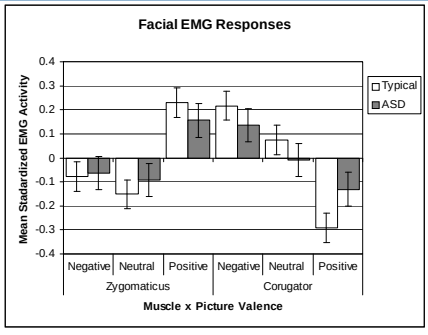
Affective Startle Modification in Autism and Typical Participants



Ratings of picture valence in autism and typical participants



Mean standardized log EMG activity over zygomaticus and the corrugator supercilli. First 2000 ms of viewing affective picture stimuli.



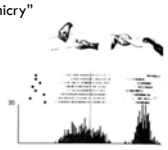
Summary of startle modification study

- Autism participants show an atypical pattern of affective startle modulation, indicating deficits in early affective processing.
- These deficits could be related to the activity of the amygdala, supporting the "amygdala theory of autism"
- However, participants show NO differences from typicals when rating the valence of pictures.

Other theories of Autism

"Broken-mirror" theory

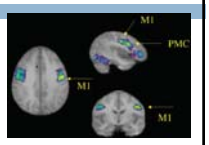
- Mirroring = recreation (simulation) of the state in oneself
- Perhaps supported by the "Mirror-neuron" system that maps other's behavior to one's own reactions.
  - Animal Example: Monkey see – monkey do
  - Human Example: Finger-movement "mimicry"

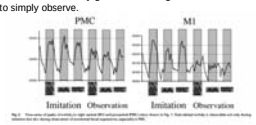


FMRI evidence for the role of the "mirror-neuron-system" in perception of emotional facial expressions
(Carr et al., 2003)

Stimuli:
-happy, sad, angry, surprise, disgust, and afraid (whole, mouth, eyes)
- 4 seconds

Task:
- imitate and internally generate the target emotion
- to simply observe.





Autistic participants show less mirroring